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Guidelines for Managing Vegetation on Earth-Covered Magazines Within the U.S. Army Materiel Command

Antonio J. Palazzo, Lawrence W. Gatto and William Woodson May 1994

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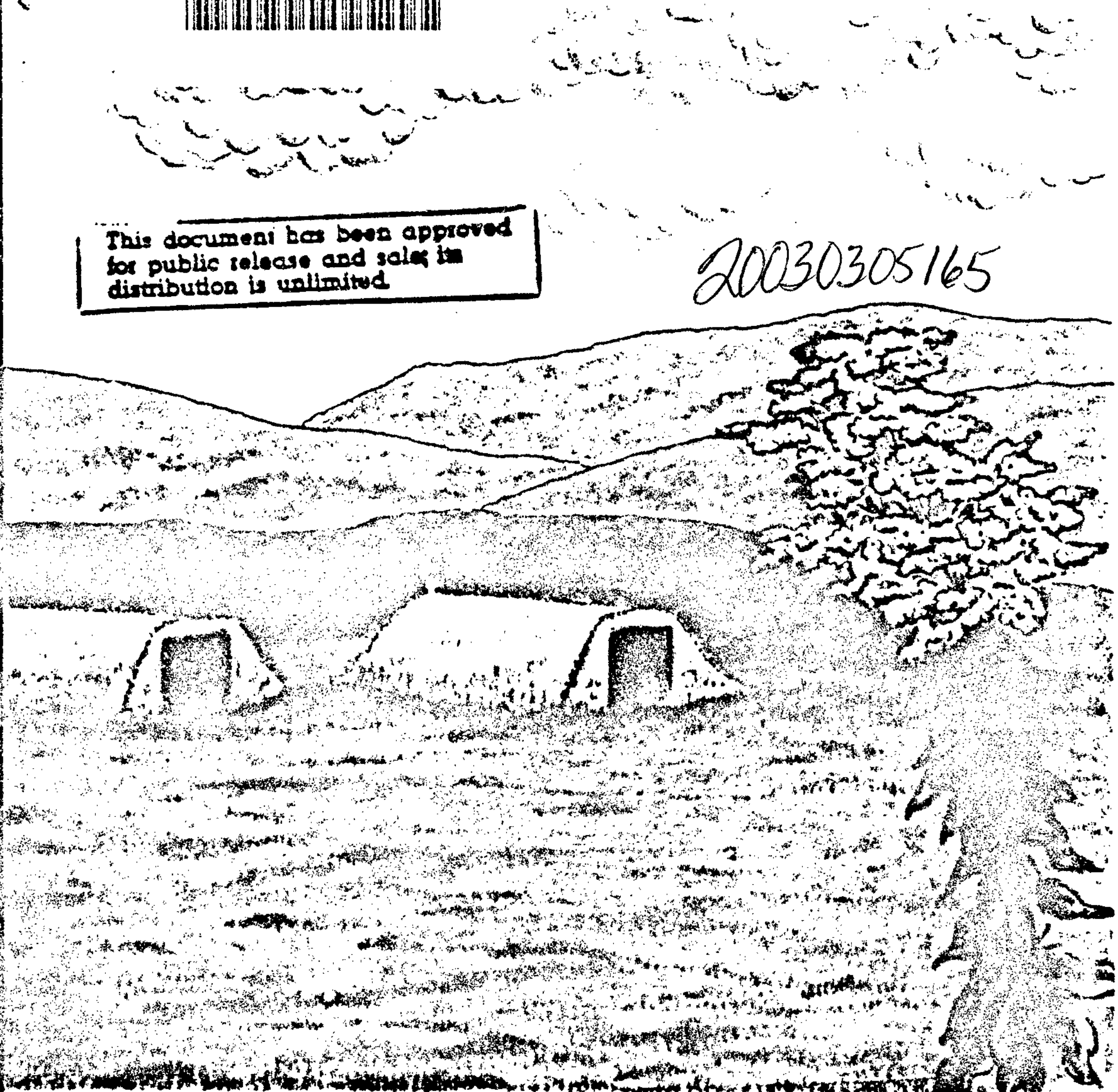

Abstract
The purpose of these guidelines is to assist land managers in establishing and maintaining vegetation on earth-covered magazines (ECMs) in a safe, efficient and cost-effective manner. Although the vegetation management procedures discussed here are intended primarily for conventional storage ECMs, not those used for special weapons, many of the general procedures and principles presented apply to both types. In humid areas a healthy vegetative cover on ECMs is the primary factor in maintaining the stable soil cover that is required to meet safety standards. Thus, a vegetation management planning process is presented that assists land managers in defining management goals, assessing climatic and soil factors and evaluating vegetation options. Specific methods and procedures that have proven successful for maintaining and re-establishing an effective vegetation cover are outlined. Other methods used to stabilize the ECM soil cover in dry climates, where cost-effective maintenance of vegetation can be difficult to impossible, are briefly discussed as well.

For conversion of SI metric units to U.S./British customary units of measurement consult ASTM Standard E380-89a, *Standard Practice for Use of the International System of Units*, published by the American Society for Testing and Materials, 1916 Race St., Philadelphia, Pa. 19103.

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US Army Corps
of Engineers
Cold Regions Research &
Engineering Laboratory

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May 1994

Prepared for
ARMY MATERIEL COMMAND

PREFACE

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ANTONIO J. PALAZZO, LAWRENCE W. GATTO
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I. INTRODUCTION

Ia. Purpose of these guidelines

About 18,500 earth-covered magazines (ECMs) are under the jurisdiction of the Army Materiel Command (AMC) at 39 installations in 23 states (Fig. 1). There are different types of ECMs, but the Stradley is the most common. These ECMs are designed, built and maintained to meet safety and security requirements as defined in Army and AMC regulations and manuals (Table 1). These regulations do not specify standard vegetation require ments but generalize about vegetation limitation on conventional weapons magazines. Therefore, th natural resources or land manager has wide latitud in using vegetation to ensure ECM slope stability.

Because of steep slopes, poor soils, exposun grazing animals and other factors, the establishmer and maintenance of vegetation on ECMs is often ex tremely difficult. Some of the more severe problem in vegetation management are shown in Table : Slopes are often too steep for heavy tillage and mair

Figure 1. AMC facilities with ECMs.

Table 1. Army documents that govern the maintenance of earth-covered magazines (ECMs).

Document	*Applicable requirements*
Safety:	
AR 385-64, Ammunition and Explosives Safety Standards (Final draft is pending publication; facilities are operating under the draft guidance)	Does not specify vegetation requirements
AMC-R 385-100, Safety Manual and Change 1	Currently requires that Part II of a natural resources management plan provide a strategy to minimize fire danger
DA PAM 385-64, Ammunition and Explosives Safety Standards (Will be revised following publication of AR 385-64)	Vegetation control will be determined by the local commander and should limit the probability of fires and maintain a balance with other operational factors
	Fire-resistant vegetation should be used whenever possible
	Shrubs and trees are not precluded but their weight and roots should not damage the structure
TM 9-1300-206, Ammunition and Explosives Standards and Change 10	Does not specify vegetation requirements
AR 385-10, Army Safety	Does not specify vegetation requirements
Facilities Engineering:	
AR 420-74, Natural Resources Land, Forest and Wildlife Management (Currently being revised)	Provides general vegetation and land management guidelines
TM 5-630, Natural Resources Land Management	Provides general vegetation management guidance
Security:	
AR 190-11, Physical Security of Arms, Ammunition and Explosives	Provides no vegetation requirements for ECM surfaces
AMC Supplement 1, 190-11, Physical Security of Arms, Ammunition and Explosives	Provides no vegetation requirements for ECM surfaces
AR 190-13, The Army Physical Security Program	Provides no vegetation requirements for ECM surfaces

Table 2. Survey responses concerning vegetation management problems with ECMs (Palazzo et al. 1991).

Problem	*Severity (% of facilities reporting)*
Soil erosion	50% have minor erosion
	37% have moderate to severe erosion
Insufficient knowledge of texture or fertility	86% have no quantitative information
Burrowing animals	32% report damage

tenance equipment to operate safely, so maintenance-free or low-maintenance vegetation must be used. In addition, most ECMs were constructed in the 1940s and 1950s, so the repair, renovation and revegetation of many of them is needed or underway, making the need for better, more efficient vegetation management techniques immediate.

The establishment and maintenance of an adequate vegetative cover on ECMs help control soil erosion and thereby maintain the minimum 2 ft of earth cover required by AMC-R 385-100. If soil loss results in less than the 2 ft of cover, an ECM may have to be re-covered and stabilized. ECMs could also become covered with undesirable vegetation (thistle, weeds, etc.) that does not retard soil erosion.

Another important part of vegetation management is maintaining vegetation at a height and density that will neither obscure the ventilation indicator flag nor restrict foot access to the top of an ECM for periodic soil depth checks. Ideally the vegetation on an ECM would be low-growing, require little or no maintenance, retard soil erosion, not be a fire hazard, resist invasion by woody and weedy herbaceous species and not be desirable to livestock where grazing is permitted.

Clearly, managing the vegetative cover on ECMs is extremely important and must meet many requirements. The purpose of these guidelines is to assist land managers (App. A) in establishing and maintaining ECM vegetation in a safe, efficient and cost-effective manner. This report attempts to address unique management techniques that are not normally found in more general land management guidelines. Recommendations presented in these guidelines or developed for a particular site with reference to the guidelines should be incorporated into the Natural Resources Management Plan and Installation Master Plan at each AMC facility.

The management procedures discussed in these guidelines are intended primarily for conventional storage ECMs, not those used for special weapons; however, many of the general procedures and principles apply to both types of ECMs. These guidelines focus primarily on vegetation as the soil stabilizing element, but 40% of the ECMs exist in dry areas where other material, in combination with vegetation or alone, may be used to maintain the soil cover. Some of the methods used in these dry climates are briefly discussed.

Ib. Format of these guidelines

These guidelines are structured so an AMC land manager can obtain general information about the planning process for managing vegetation, as well as specifics on vegetation maintenance and establishment techniques. Vegetation maintenance is dealt with first because more time and money are spent maintaining vegetation than establishing it. The sections on the specific maintenance techniques include uses, costs, efficiencies, effectiveness, timing, safety and possible environmental hazards associated with each technique. Finally the guidelines include numerous appendices that land managers can use as they develop their vegetation management plans. Appendix B lists literature references used to obtain some of the information presented here. Literature citations are not included in the guideline text to keep the text as easy to read as possible.

The guidance provided here is based on current knowledge and ideas, which are continually changing. Suggestions for changes and additions should be mailed to: Commander, AMC Installations and Services Activity, Attn.: AMXEN-M, Rock Island, IL 61299-7190.

II. VEGETATION MANAGEMENT PLANNING

A recent survey of AMC land managers has shown that it is expensive to maintain ECMs. Therefore, the land managers should develop and implement a vegetation management plan to meet established maintenance goals as economically as possible. Appendix C shows the steps to follow in developing the plan. To be successful, the plan should be developed as early as possible before vegetation operations to allow for review by Safety and Security Offices so that all aspects of maintaining ECMs can be considered. Once these offices have approved the planning document, the Quality Assurance Office should be told how the maintenance operations will be conducted. The plan should consider the revegetation goals of all concerned offices, the soils, the microclimate, the type of vegetation best suited for the site, the level of maintenance desired after construction is completed and the cost and feasibility of revegetation alternatives. This section describes the general steps to be taken by a land manager in evaluating and developing vegetation management concepts and the plan (Fig. 2).

IIa. Assessment of management goals

Vegetation management goals must be determined and assigned priorities at each AMC facility. The goals, and the intensity of treatment(s) to meet those goals, will depend on the projected long-term needs and site characteristics of a facility, such as climate, soil types, fertility, plant availability and costs. Management goals usually achieved by establishing an acceptable vegetation cover include maintaining ECM soil stability and reducing maintenance costs.

A vegetative cover should keep erosion at an acceptable level, usually about one ton/acre annually. Herbaceous species, mainly grasses, are usually the dominant vegetation type. Newer varieties of standard species are continually being developed that will meet established goals, and land managers should not always rely on the "old standard mixture

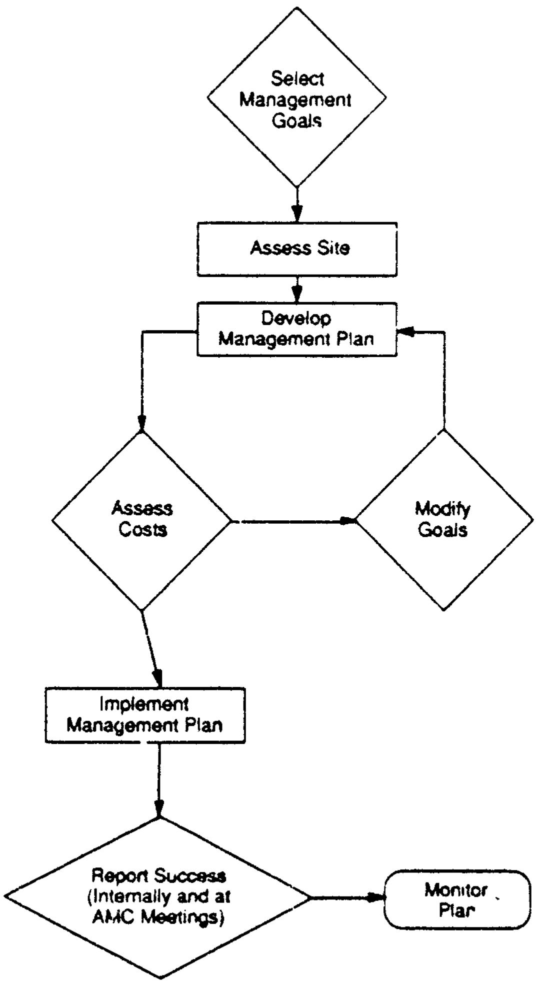

Figure 2. Steps involved in developing and implementing a revegetation management plan.

of species." Buying "common" varieties or cultivars may lead to vegetation with inappropriate growth habits and management problems. Managers should also inquire of upper management if more latitude in the types of acceptable vegetative cover are possible, for example, intentionally planting trees or allowing woody species to invade ECM slopes and mowing a path to the ventilator flag for foot traffic and line-of-sight observation. New approachs could reduce labor requirements and costs.

Stabilizing the soil surface on ECMs is often the primary goal. Soil stability can be improved by reducing water or wind erosion or minimizing freeze–thaw effects. Herbaceous vegetation, such as grasses and legumes, is usually selected to provide soil stability because it is quick and economical to establish and relatively easy to maintain. Selecting appropriate plant species mixtures and establishing management techniques that require low maintenance will reduce labor and materials costs. These techniques may be different from those previously followed, and the land manager should explain the changes and the resulting benefits to the installation administrators.

Vegetation establishment, however, may not be the sole solution. For example, on highly unstable slopes, engineered slope controls such as terracing may be needed to ensure stability. Alternatives for dry areas include soil stabilizers or aggregate covers with emulsifiers.

At some point land managers must develop criteria by which to evaluate whether their vegetation establishment and maintenance goals have been met. Success criteria may include reaching a predetermined percentage of vegetation cover within a given time or the reduction or elimination of particular weedy species. Evaluating success should be part of ECM management plans.

IIb. Climatic zones and plant selection

Climatic conditions are important for maintaining and establishing vegetation and must be considered in developing vegetation management plans. AMC ECMs are located in four major climatic areas:

- Dry (7 facilities, 40% of the ECMs);
- Dry–humid transition (7 facilities, 20%);
- Warm, humid (5 facilities, 14%); and
- Cool, humid (15 facilities, 26%).

The kinds of grasses and legumes recommended for seeding will vary with geographical area because the adaptation of a species to local climatic conditions is important to the likelihood of its successful growth.

The climatic factors that influence revegetation and growth are:

- Amount and distribution of precipitation;
- Soil type;
- Air temperature patterns;
- Length of growing season;
- Wind;
- Humidity;
- Solar insolation;
- General seasonal variation;
- Microclimatic variations on north- and south-facing slopes;
- Proximity and orientation to large bodies of water; and
- Altitude.

In the arid and semiarid west, extensive flat, minimally vegetated areas contribute to strong, persistent winds, which increase evapotranspiration. Regional wind velocity and direction can be obtained from the nearest weather station. Climatic summaries for each state are available from the National Weather Service.

IIc. Flammability

Ten AMC facilities with ECMs are located in regions where wildfires occur one or more times per year. The chance that fire will burn over an ECM is a function of the ignition source (lightning or human), the weather and the type and quantity of fuel on the ECM. The steep slopes and elevation of ECMs promote the drying of the vegetation by the wind and, therefore, the spread of fire. Fire-danger-rating systems predict the intensity, rate and direction of fire spread, while fire-fuel models compute the rate of spread, flame length and available energy based on the structural, chemical and moisture characteristics of the vegetation fuel. In most models a major distinction is made between fuel grass 0.5 and 1.5 ft high and grass greater than 3 ft. The importance of this consideration increases at AMC facilities located in regions of the country where wildfire is common, as in the arid grasslands and shrublands of the western U.S.

Annual grasses like cheatgrass have high flammability because they often die early and cure or dry quickly. Perennial grasses that are short, have a wide blade, maintain green foliage and have a low proportion of standing dead leaves are less flammable. A survey of four native grasses in Texas found that buffalograss was the least flammable; bluegrass (*Poa* sp.) flammability is also low.

Biomass (fuel loading), fuel moisture, compactness of fuel, amount of finely divided fuels, fuel continuity, mineral content in the vegetation, volatile compounds in the vegetation and carbohydrates in the vegetation are the plant properties that determine vegetation flammability and influence the intensity and spread of fire. Although plant chemistry is important in evaluating vegetation flammability, the ratio of dead to live vegetation and the distribution of litter on the ground is more important. Species that produce more biomass with fine leaves and branches are most flammable; grasses are more flammable than broadleaf forbs. Clumped and sparse vegetation and plants with high ash and moisture content and low calorie content tend to be less flammable than more continuous vegetation with low ash and moisture contents.

Therefore, selection of species for revegetation of ECMs should consider their fire-resistant or fire-retardant characteristics: low dead-to-live ratios, low oil and resin contents, coarse rather than fine leaves and stems, and succulent (high moisture) rather than hard, dry foliage. In general, most cool-season grasses have lower dead-to-live tissue ratios more months of the year than do warm-season grasses. Reduction in the amount of fuel and increases in the discontinuity of fuels are probably the most important characteristics. The access roads within ECM areas serve as firebreaks.

Although all burns that occur at AMC facilities are not set, burning has been used as a cost-effective method of vegetation control. Grassland burning reduces weed seed numbers in the soil and increases soil fertility and reduces biomass. Although controlled burning is a proven technique, it is not deemed practical for vegetation control at this time.

IId. Trees

The planting of woody species on ECMs is a relatively new idea in the United States, but it has been done in Europe since World War II. On U.S. Army installations in Germany, trees are grown on ECMs, with plans for harvesting them for poles and pulp after 15–20 years. Trees are also planted between ECMs to provide shade for ECM slopes, which reduces drying of the slopes. Various tree-harvesting scenarios may be developed depending on the tree size, market factors and types of trees planted.

A major benefit in growing trees is the reduction of annual maintenance costs when the trees are actively growing. The primary savings will result from not mowing the ECM slopes. Several drawbacks may exist. One is the increased costs and labor involved in planting the trees and the initial care, which will probably last for two or three years. Another potential drawback is the growth of the roots around an ECM, with possible damage to it. No problems in this regard have been noted in Germany, although definitive studies to document the effects of tree roots on the internal structure of ECMs have not been done. Another drawback is the need to remove fallen limbs and leaves to reduce fire potential. Grazing lands, and the resulting income, may also be lost, although trees could be planted only on the slopes of the ECM, leaving grass between them.

The effect of a tree upon an ECM's Lightning Protection System (LPS) is not known. If the tree were to grow taller than the LPS, it may attract lightning away from the LPS. Current regulation requires the LPS to be taller than surrounding ob-

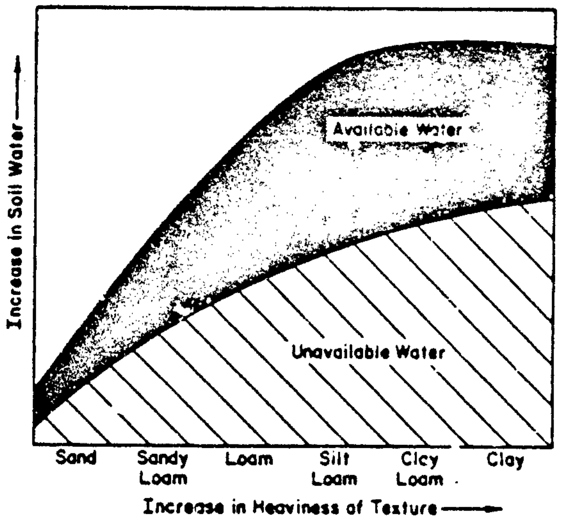

Figure 3. General relationship between soil moisture characteristics and soil texture. Unavailable water is bound up with the soil particles and cannot be used by plants; available water is in pore spaces between sediment grains and can be used by plants. (After Brady 1974.)

jects. The tree's root system may offer an alternative path for the lightning stroke to enter the magazine and bypass the LPS.

Although questions remain regarding the advisability of growing trees on ECMs, they should be considered because of their low maintenance costs. This concept is being tested at Bluegrass Army Ammunition Depot. Updates will be provided as they are made available by the U.S. Army Materiel Command Installations and Services Activity.

IIe. Soil monitoring

Characterizing on-site soils is important in developing a site management plan for either vegetation maintenance or establishment because the soil type directly influences a plant's growth potential. Soil type is based on physical, chemical and biological properties of the soils. Because ECMs are man-made structures, the soils covering them are likely to be different from the surrounding soils described on soil surveys. Consequently it would be necessary to sample soils from several ECMs to determine their properties.

The growth potential of a site is its ability to maximize initial plant growth until soil stability and related conditions are met. The growth potential of a site can be assessed in two ways. Site characteristics can be visually rated by trained personnel at low costs based on the level of knowledge needed. If more thorough knowledge is needed, the site characterization may involve more elaborate quantitative procedures that require more labor and money.

The growth potential of a site can be visually assessed according to its ability to provide adequate moisture and nutrients and a favorable microclimate for plant growth. Adequate moisture will be determined by the amount of fine-grained particles in the soil (Fig. 3), the amount of soil organic matter and the climate. In general, coarser-grained soils hold less water for plant growth but also provide greater aeration for better root growth. Organic materials in soils improve plant growing conditions by improving moisture- and nutrient-holding capacities and soil structure. Optimum soils for plant

Table 3. Soil and climatic conditions increasing the likelihood of plant nutrient deficiencies (Chapman 1966).

Nutrient	*Conditions making deficiency likely*
Nitrogen	Sandy soils, high rainfall, low-organic-matter soils.
Phosphorus	Highly leached soils, organic soils, calcareous soils, cold soils.
Potassium	Sandy soils, organic soils heavily cropped, leached and eroded soils.
Calcium	Sandy soils, high rainfall, acid soils, mineral or peat, clay (principally montmorillonitic), alkali or sodic soils.
Magnesium	Acid sandy soils, organic soils.
Sulfur	Low-organic-matter soils, small quantity of sulfur brought down in rainfall.
Iron	Calcareous soils, poorly drained soils, high soil levels of P, Mn, Zn, Cu or Ni.
Copper	Organic soils, alkaline and calcareous soils, leached sandy soils, heavily nitrogen fertilized.
Zinc	Acid, leached, sandy soils, alkaline soils, soils derived from granites.
Manganese	Thin peaty soils over calcareous subsoil, calcareous silts and clays, poorly drained, high-organic matter calcareous soils very sandy acid mineral soils.
Boron	Sandy soils, soils derived from acid igneous rock, naturally acid leached soils, acid organic soils, alkaline soils with free lime.
Molybdenum	Highly podsolized soils, well-drained calcareous soils.

growth potential are midway between coarse and fine texture and between organic and mineral.

Soil and climatic conditions where nutrient deficiencies are likely to occur are shown in Table 3. However, routine soil tests to determine the soil pH and the status and availability of the more important nutrients must be done to determine site fertility. Local state university extension services will usually do these tests at minimal costs. They will also advise on soil sampling techniques, such as appropriate depth, composting and sample size. The soil samples collected for these tests should be taken from representative areas as determined by variability in soil type, size of the site and allowable cost.

Soil pH is important because of its direct effect on plant growth and its indirect effects on plant nutrient availability and elemental toxicity in soils. Soil pH is usually measured to test the need for lime, although a buffer pH measurement is also needed to determine the quantity of soil acidity to be neutralized to change the soil pH. If soil acidity is below 5.5 or above 8.0, it should be modified; the most widely used materials to raise and lower soil pH are limestone (Table 4) and sulfur, respectively. Soil pH ranges for optimum availability of nutrients for the growth of several grasses are shown in Table 5. In general the optimum pH range is 5.5–7.5.

When removal of the earth cover for restoration or repairs is planned, the land manager must specify to the construction planners how much of the construction spoil should be stockpiled for revegetation use. The amount and type of topsoil and the type of subsoil should be determined before or during the initial disturbance. Soil samples from borehole data can be used to obtain this information prior to clearing an ECM. The amount of topsoil can be critical in successfully revegetating disturbed areas. Topsoil depths from 4 to 30 in. can be stockpiled in an accessible area and reapplied prior to seeding. If topsoil is not available, it still may be worthwhile to place a fine-grained subsoil (silt) over a coarse-grained (gravel) surface. In situatior where there is only a thin veneer of topsoil or o ganics (less than 4 in.), it is usually neither feasib nor economical to segregate it. Seeding directly o coarse-grained soils, such as gravels, will requi special soil amendments and techniques, such a those discussed in Section IIe1. Properly treate sewage sludge, composted sewage sludge, com posted leaves, composted yard waste, manures o other proven sources of organic matter are valuabl assets to vegetation establishment, particularly u der difficult circumstances involving lack of moi ture and nutrients.

IIe1. Plant nutrients

At least 17 plant elements are necessary for pla growth and for improving plant health and surviv ability. Carbon, hydrogen and oxygen are obtaine from carbon dioxide and water, and nitrogen, pho phorus, sulfur, potassium, calcium, magnesiun iron, manganese, zinc, copper, molybdenum, b ron, chlorine and nickel are obtained from the soi Symptoms of nutrient deficiencies in plants a shown in Table 6, and methods for correctin nutrient deficiencies are shown in Table 7.

Once a low-maintenance vegetative stan is established, nutrients are recycled withi the plant–soil ecosystem. Nutrient recyclin may be enhanced through the use of legume the addition of organic matter and the appl cation of fertilizer. Fertilizers can differ i their rate of release of nutrients into the soi In general, chemical fertilizers are less expe sive and release their nutrients more rapidl than specially formulated slow-release ferti

Table 5. Range of pH for optimum growth of various grasses. (From Beard 1973.)

Common name	*pH range*
Annual bluegrass	5.5–6.5
Canada bluegrass	5.5–6.5
Rough bluegrass	6.0–7.0
Kentucky bluegrass	6.0–7.0
Colonial bentgrass	5.5–6.5
Creeping bentgrass	5.5–6.5
Velvet bentgrass	5.0–6.0
Redtop	5.0–6.0
Creeping red fescue	5.5–6.5
Chewings fescue	5.5–6.5
Sheep fescue	4.5–5.5
Tall fescue	5.5–6.5
Ryegrasses	6.0–7.0
Timothy	6.0–7.0
Bahiagrass	6.5–7.5

Table 4. Relative neutralizing value of six common forms of lime. (After Miller et al. 1965.)

Liming material	*Chemical formula*	*Relative neutralizing value (%)*
Magnesium oxide	MgO	250
Calcium oxide	CaO	178
Magnesium hydroxide	$Mg(OH)_2$	172
Calcium hydroxide	$Ca(OH)_2$	135
Magnesium carbonate	$MgCO_3$	119
Calcium carbonate	$CaCO_3$	100

Table 6. Symptoms of nutrient deficiencies in plants. The table is generalized, and symptoms may be different for different species. (Adapted from text in Epstein 1972.)

Nutrient deficiency	*Symptoms*
Nitrogen or sulfur	Chlorotic (yellowed); etiolated (spindly); slow growth; mature parts affected first.
Phosphorus	Dark- or blue-green foliage; red, purple or brown in leaves along veins; slow growth.
Potassium	Dark- or blue-green foliage; necrotic (dead) regions on leaves; slow growth.
Calcium	Buds and young leaves are damaged and may die (die-back); slow root growth.
Magnesium	Becomes chlorotic in blotches; pigmentations may develop; mature parts affected first.
Iron	Young leaves become chlorotic.
Copper	Variable: chlorosis; pigmentation; die-back.
Boron	Buds are damaged; leaves may become distorted.
Molybdenum	Chlorotic; mottled; necrotic.

Table 7. Methods of correcting certain plant nutrient deficiencies. (After Chapman 1966.)

Nutrient	*Method for correcting deficiency*
Nitrogen	N fertilizer applied to soil or foliar spray of soluble N carrier. Add organic matter to the soil.
Phosphorus	Apply plant-available source of phosphorus to the soil. Adjust extreme pH.
Potassium	Apply potassium-bearing fertilizer to soil.
Calcium	Lime acid soils. Add gypsum or other soluble calcium source where lime is not needed.
Magnesium	Add dolomitic limestone. Where lime is not needed, make a soil or foliar application of epsom salts (magnesium sulfate).
Sulfur	Use fertilizer salts containing sulfur (i.e. ammonium sulfate, potassium sulfate, low-grade phosphate). Apply gypsum or elemental sulfur.
Iron	Foliar spray of iron sulfate or soil application of chelated iron. Lower pH, improve drainage, reduce phosphorus fertilization.
Copper	Foliar or soil application of copper sulfate. Reduce nitrogen fertilization.
Zinc	Foliar spray of zinc sulfate or soil application of zinc chelates.
Manganese	Foliar spray of manganese sulfate.
Boron	Foliar or soil application of borax. Neutralize soils containing free lime.
Molybdenum	Soil or foliar application of sodium or ammonium molybdate. Lime acid soils.

izers. Slow-release fertilizers may have to be used at higher rates and will release nutrients over a greater part of the growing season. They may be necessary on coarse substrates, such as sands and gravels, where the nitrogen portion of normal chemical fertilizers is rapidly leached away.

Fertilizer selection should be based on plant types. For example, grasses require higher application rates of nitrogen than do legumes. In contrast, legumes and other nitrogen-fixing plants require only small amounts of nitrogen but need large amounts of phosphorus and potassium for establishment. Excessively high rates of fertilizer not only increase costs, but they can retard the growth of some slow-growing native species. In general, fertilizer rates should be as low as possible while ensuring adequate plant growth for erosion control or other site-specific goals. Composted materials (sewage sludge, leaves or other organic materials) are sometimes considered economical slow-release fertilizers. Besides adding nutrients, organic materials improve the structure of marginal soils. Such materials are usually tilled into the soil but are also helpful when spread over newly sown areas, where they serve as a moisture-conserving mulch and deterrent to soil crusting.

Local environmental laws should be reviewed to determine if permits are required to apply the organic materials. AMC recommends that land for application of organic materials be reserved for

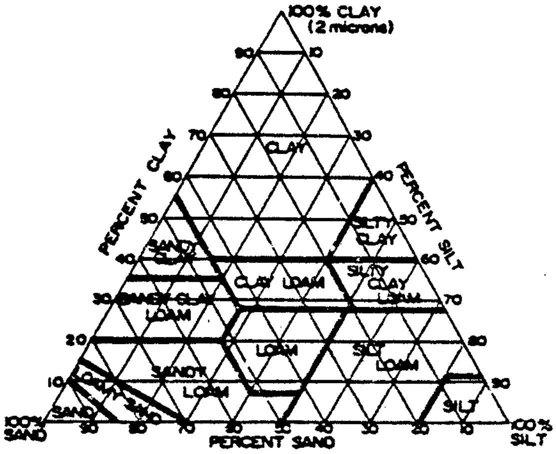

Figure 4. Soil textural triangle showing the percentages of sand, silt and clay in the soil classes using USDA definitions. (After Donahue 1965.)

"Army only" application. Applying organic wastes from neighboring municipalities is not recommended because it utilizes land that may eventually be needed for Army waste management.

IIe2. Texture

Soil texture is a measure of the proportions of sand, silt and clay. Sand, when dominant, forms a coarse-textured, or light, soil that allows water to infiltrate rapidly. Silts and clays make up fine-textured, or heavy, soils, and depending upon the clay mineralogy they can be quite cohesive and slow to erode. Soils that are high in silt and fine sand and low in clay and organic matter are generally the most erodible. Appendix D describes the equations for estimating soil loss due to sheet, rill and wind erosion. General soils descriptions should be developed for ECMs through soil surveys that include soil particle-size groups as determined by a mechanical analysis using standard sieves or by the hydrometer method or both. A soil's textural name is then determined by inserting the resulting sieve data of each group in a textural triangle (Fig. 4, Table 8).

IIe3. Physical measures to control erosion

Historically, physical measures have not been used during the construction of ECMs, even though past requirements called for a minimum slope of 1 on 1.5 (rise on run). Present regulations call for a minimum slope of 1 on 2, which will still require more maintenance than gentler slopes (Fig. 5). A better scenario would have slopes constructed at 1 on 3. This would increase revegetation success and reduce management costs. If physical measures are required, water bars (to slow the flow of water) and contouring (to direct drainage) should

Table 8. Soil textural classes and general terminology used in soil descriptions.

General terms		
Name	*Texture*	*Basic soil textural common class names*
Sandy soils	Coarse	Sand
		Loamy sand
	Moderately coarse	Sandy loam
		Fine sandy loam
	Medium	Very fine sandy loam
		Loam
Loamy soils		Silt loam
		Silt
	Moderately fine	Clay loam
		Sandy clay loam
		Silty clay loam
Clayey soils	Fine	Sandy clay
		Sandy clay
		Silty clay
		Clay

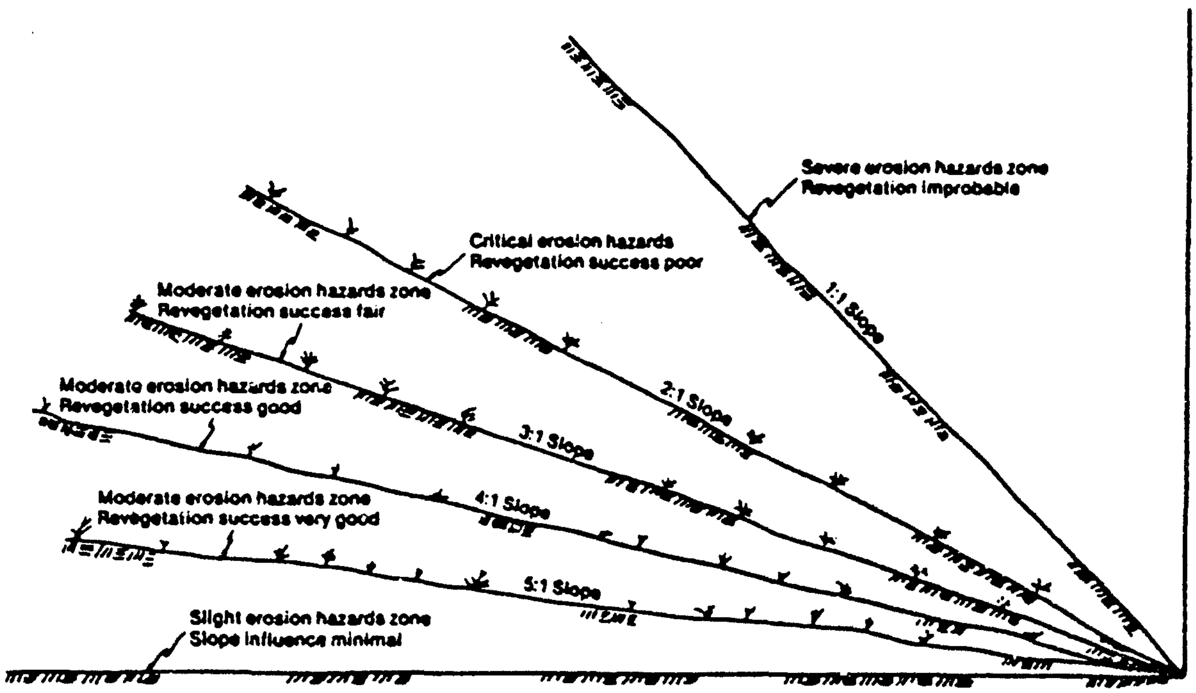

Figure 5. Influence of percent slope on revegetation. (From Nevada State Conservation Commission, n.d.)

be considered, with swales constructed below the slope to collect and remove all drainage water. Such swales should be well vegetated to prevent erosion along the toe of the ECM slopes.

III. MAINTENANCE OF EXISTING VEGETATION ON ECMs

IIIa. Vegetation maintenance goals

The land manager should strive for a management plan that leads to minimum maintenance of the existing vegetative cover. The ideal situation would be vegetation that requires no maintenance, but this is rarely possible because unattended vegetation will change in composition and then may no longer serve its intended purpose. If this is allowed to continue, the site usually degrades, water and wind erosion becomes a problem, and very expensive, remedial revegetation practices may be required. Therefore, ECMs should be routinely monitored to detect and correct problems that may lead to such conditions.

Most ECMs require periodic maintenance to sustain an adequate protective cover, and the schedule and kind of maintenance should be part of any management plan. For example, fertilization may be needed to improve a vegetative stand, and herbicides may be required to control tall vegetation around ventilators. However, the use of herbicides and brush-cutting equipment can be minimized by using selective herbicides, by cutting woody vegetation only at certain times of the year and by encouraging the establishment and growth of acceptable, low-growing herbs and grasses around ventilators to minimize invasion by other species.

IIIb. Site assessment

Land managers must familiarize themselves with local conditions that affect their site by doing site evaluations with regional or local technical experts, noting those site characteristics and situations that may prevent appropriate plant growth. They will need enough resources and funding to avoid expensive consequences. Situations managers must watch for include:

- ECMs with south- and southwest-facing slopes that are hard to vegetate;
- Very poor or highly erodible soils on ECM slopes;
- Invasions by weeds that prevent the growth of desirable vegetation;
- Slopes that are too steep; and
- Overgrazing.

Land managers must determine the priority of problems by considering the potential effect on a facility's mission if left uncorrected.

IIIc. Specific maintenance practices

Sections IIIc1–9 describe some of the advantages and disadvantages of each technique and will aid AMC land managers in preparing a vegetation management plan. The goal of all the techniques is to maintain a low-cost protective cover on ECMs that meets the needs of a particular facility.

All maintenance operations should be planned for the season when the benefits will be greatest or the costs will be least. For example, if mowing is required, it could be done near the end of a rapid plant growth time instead of every two weeks or monthly throughout the year.

IIIc1. Practice: No vegetation maintenance

a. Possible uses:

- Alternate periods of no maintenance with periods when other maintenance techniques are used to reduce overall long-term costs.
- Allows a vegetative cover to change composition and to decrease its areal extent in anticipation of starting a new vegetation stand.
- In dry areas, allows vegetation cover to occupy sites where aggregate has been applied.

b. Relative expense:

- Low initial cost.
- Can lead to expensive remedial work, either to rebuild an eroded ECM slope or to re-establish acceptable vegetation on a slope left unmaintained for too long.

c. Efficiency of human resource use:

- High because few resources are used when no maintenance is required.

d. Relative effectiveness:

- Could lead to soil instability due to thinning turf and deteriorating and changing plant cover, with subsequent water and wind erosion depending on site conditions and climate.

e. Optimum timing:

- None.

f. Safety risk:

- Low because few activities are required.

g. Environmental hazards:

- None.

IIIc2. Practice: Mowing

a. Possible uses:

- Reduces fire hazard.
- Lowers plant height to allow viewing of and access to vent and ventilator flag.
- Reduces woody plant growth.

b. Relative expense:

- High because mowing equipment must be maintained and fueled.

c. Efficiency of human resource use:

- Low because mowing is time-consuming.
- Could restrict mowing to only around ventilators.
- Mowing is not recommended in AMC–R 385-100.

d. Relative effectiveness:

- Moderate to low overall.
- Immediate effectiveness is high but short-lived where vegetation grows fast.
- Mowing may damage shaped slopes.
- More than 50% of the AMC facilities (with 72% of the ECMs) don't mow ECMs.

e. Optimum timing:

- Mow grasses near end of periods of rapid growth.
- Mow wildflowers in the fall.
- Some legumes do not need mowing.

f. Safety risk:

- Moderate to high due to hazards inherent in mowing a slope.
- Mowing gets more hazardous as the slope steepens.

g. Environmental hazards:

- Uses small amounts of fossil fuels and has only a slight impact on air quality.
- Mower wheels sear steep banks, inviting weed invasion and erosion.

IIIc3. Practice: Application of fertilizers and lime/sulfur

a. Possible uses:

- Can aid in establishing new seedings.
- Reduces weed invasion and improve stand of desirable vegetation.

b. Relative expense:

- Moderate depending on existing vegetative cover.
- Application rates of chemical fertilizers depend on climate; in the east, rates are usually about 40–80 lb/acre of nitrogen and about 40 lb/acre of phosphorus and potassium per year; in colder climates, rates of up to 60 lb/acre of phosphorus and potassium are frequently required.

c. Efficiency of human resource use:

- Moderate to high because after initial fertilization and liming, plants will grow better and require less maintenance except for mowing.
- Important to accurately determine the amount of fertilizer and lime required to minimize labor (soil tests).

d. Relative effectiveness:

- High because a vegetative stand may fail without proper nutrients.

e. Optimum timing:

- In humid areas, fertilizer should be applied in the fall to limit topgrowth.

f. Safety risk:

- Low.

g. Environmental hazards:

- Low.

IIIc4. Practice: Application of herbicides

a. Possible uses:

- Rids ECM slopes of undesirable plants that allow soil erosion, adversely affect grazing, obscure ventilator flags or restrict access to an ECM ridge; consult TM 5-630 and local university extension services for herbicides since such recommendations are subject to change.

b. Relative expense:

- Moderate to high.

c. Efficiency of human resource use:

- High because once a herbicide is applied, unwanted vegetation will be eliminated for at least one growing season and probably three or more.
- Must be applied by trained and certified personnel (AR 420-76).

d. Relative effectiveness:

- High.

e. Optimum timing:

- Extremely important; varies with vegetation, climate and herbicide.

f. Safety risk:

- Moderate but potentially high if safety precautions are not followed.
- Labels contain detailed precautions.
- Worker exposure.

g. Environmental hazards:

- Can impact endangered and other non-target species, contaminate water supplies and become wind-borne during application, possibly impacting or contaminating distant locations.
- Can kill legumes.

IIIc5. Practice: Application of plant growth regulators (PGRs)

a. Possible uses:

- Suppresses vegetation on EMCs and other difficult-to-mow areas.
- Suppresses grass seedhead formation.
- Reduces mowing frequency and maintenance costs.

b. Relative expense:

- Cost-effective if applied correctly.
- Savings depend on cost of chemical and its application vs current cost of mowing.

c. Efficiency of human resource use:

- High because of reduced mowing.

d. Relative effectiveness:

- High; manufacturer's label recommendations must be followed to obtain desired results.
- PGRs are compatible with most turfgrass herbicides.
- Should not be considered a replacement for mowing but rather as a method to reduce mowing frequency.
- Small test plots should be established on site to determine PGR effectiveness prior to general use.
- Certain chemicals may not regulate growth throughout the year.

e. Optimum timing:

- Timing of application is critical and dictates treatment success.
- Timing of PGR applications varies with grass species and location.
- Follow label recommendations for optimum effectiveness.
- Most PGRs should be applied in spring when grasses are rapidly growing and before seedheads emerge.

f. Safety risks:

- Follow safety recommendations on manufacturer's label.
- Use licensed applicators.
- Use proper application equipment.

g. Environmental hazards:

- Possible effects to non-target vegetation: read product label for list of susceptible plant species.
- Follow restrictions listed on product label.
- Monitor treatment application and results.

IIIc6. Practice: Overseeding

a. Possible uses:

- Improves a sparse vegetative cover.

- Establishes new cover primarily for reduced maintenance.

b. Relative expense:
- Low to moderate.

c. Efficiency of human resource use:
- High.

d. Relative effectiveness:
- Sometimes unsuccessful because of inadequate seed–soil contact resulting from broadcast seeding operations (ECM slopes are usually too steep for conventional, no-till seeding equipment).
- Some success has been achieved with fine fescues (chewings, hard, sheep and red) in the transition zone of the United States.
- Long lasting if successful.

e. Optimum timing:
- Seeding on frozen soils in the spring and allowing the natural freeze–thaw action to improve seed–soil contacts (frost seeding) has the best chance of success in all but the warmest climates in humid areas.

f. Safety risks:
- No safety hazards unless tractor-drawn equipment is used on steep slopes.

g. Environmental hazards:
- None.

IIIc7. Practice: Grazing

a. Possible uses:
- Produces income that can be used to improve or maintain AMC lands (about 30% of AMC magazines are grazed).
- Helps keep vegetation under control.

b. Relative expense:
- Low.

c. Efficiency of human resource use:
- High because little labor is required.

d. Relative effectiveness:
- Often promotes weed invasion.
- Can promote erosion.
- Causes soil compaction, which retards plant growth, resulting in more downslope water flow and soil erosion.
- Proper grazing management largely eliminates the above.

e. Optimum timing:
- A plan should be implemented so the lands are fully utilized but not overgrazed.

f. Safety risks:
- Low.

g. Environmental hazards:
- Low.

IIIc8. Practice: Soil stabilizers (emulsions, asphalt cut-back, latex, etc.)

a. Possible uses:
- Temporary soil erosion control.
- Dust abatement.
- Sand stabilization.
- Tackifier for holding mulch and seed in place.

b. Relative expense:
- Medium to high.
- Application rates for each product depend on intended use, climate and degree of problem.
- Not an economical alternative where vegetation can be easily established.
- Often the most economical alternative where vegetation is difficult to establish.

c. Efficiency of human resource use:
- High because spray applications can cover large areas in little time.

d. Relative effectiveness:
- High if applied correctly.
- Depending on climate and disturbance, soil stabilizers may retain effectiveness for two years or more.

e. Optimum timing:
- Any time when soil is dry enough to support wheeled vehicles and temperatures are above freezing.

f. Safety risks:
- Most commercial products are latex-acrylic copolymers that are non-corrosive, non-toxic and non-flammable.
- Some products may cause skin, eye and respiratory irritation; protective clothing may be required.

g. Environmental hazards:
- Most commercial products may be sprayed on existing vegetation without harm.
- High concentrations of some products may harm aquatic organisms.

*IIIc9. Practice: Forestation**

a. Possible uses:
- Reduction in weed growth and mowing operations.

b. Relative expense:
- High initially, but low over a 10-year period.
- Return on investment is decades long.

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* Forestation is not recommended at this time except on an experimental basis.

Table 9. Comparisons of maintenance techniques.

	Expensive to perform	*Produces income*	*Reduces maintenance cost*	
			Short-term	*Long-term*
No maintenance			X	
Mowing	X			
Fertilizers and liming				X
Herbicides	X		X	X
Plant growth regulators	X		X	X
Overseeding	X			X
Grazing		X		
Soil stabilizers				
Forestation	X	X		

c. *Efficiency of human resource use:*
- High.

d. *Relative effectiveness:*
- Probably high but not much data available.
- Concerns for root penetration of cracked concrete.
- Concerns for lightning protection.

e. *Optimum timing:*
- Extremely important.
- Consult state forestry agency.

f. *Safety risks:*
- Low for hand planting; machine planting not recommended on steep slopes.

g. *Environmental hazards:*
- None.

IIId. Cost–benefit analysis of different techniques

It is important that early in the planning phase the land manager develop cost estimates for materials, labor, equipment and maintenance involved in each treatment being considered to assess how each fits into monetary constraints. When estimating overall treatment costs, prices for plant and other materials, including soil amendments and labor and equipment time for each operation within a given treatment, must be determined. Maintenance costs for the various treatments would include site monitoring, refertilization, herbicides, plant growth regulators, pesticides, mowing or brushing, and watering. Comparisons for each maintenance technique described in this section are summarized in Table 9.

Values used for the materials and labor costs can be chosen from local averages or from the national averages listed in *Building Construction Cost Data* (see Robert Snow Means Co., Inc., 1978, App. B), a reference to aid contractors in anticipating their construction expenses. Calculating a treatment installation cost basically involves adding all expenses.

IIIe. Evaluating success

After maintenance operations are completed, their success should be evaluated. Sample questions to ask are: Is the vegetative stand thicker after fertilization? What percentage of the weeds were controlled by herbicides? Any maintenance operation should result in a vegetative cover of more than 50% of the soil surface. The cover species to consider are desirable perennial plants and not annual weeds.

IV. ESTABLISHMENT OF VEGETATION ON ECMs

IVa. Goal assessment

The goals will likely be the same as for maintaining existing vegetation (see Section IIIa).

IVb. Site assessment

The amount of revegetation effort required at the end of construction can be greatly reduced through proper planning (Fig. 6). Previously disturbed and revegetated ECMs should be monitored to determine successes and failures of the revegetation techniques; this should be done by visiting the site, talking to the people who were in charge of the site restoration, and studying the construction and revegetation plans. The land manager should have input into the seasonal timing, species selection, renovation or construction work. This will require an extra effort in the planning stages before any contract is finalized.

Once goals for revegetation are set, but before ECM renovation begins, the land manager must

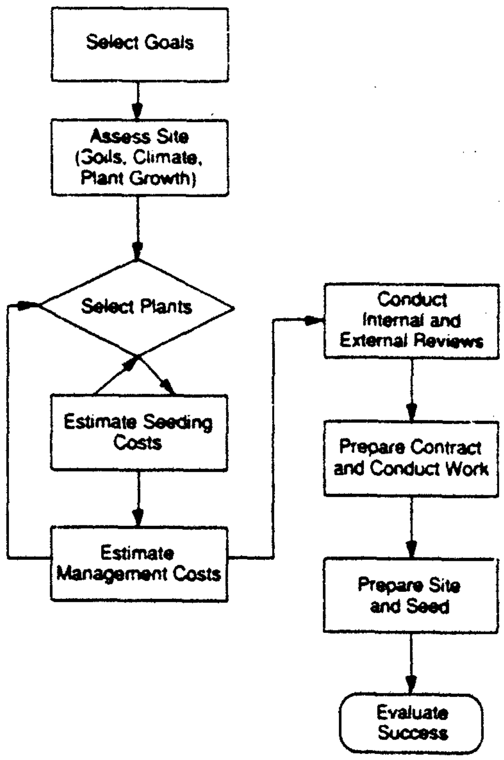

Figure 6. Steps involved in planning new seedings.

make visual assessments and soil fertility and physical tests to anticipate likely after-construction conditions and to verify the site's stability, its ability to support new plant growth and the likelihood of reinvasion by undesirable vegetation. It is not unusual for soil and climatic conditions to vary on individual facilities, making it necessary to assess ECM areas separately and develop separate revegetation plans for each area. Also, the orientation of EMCs affects vegetation performance and persistence. Southwest-facing slopes are the hottest and driest and therefore most difficult to maintain adequately.

After the revegetation goals have been established and a site's stability and ability to support growth have been assessed, the next step is to identify the specific treatments that will meet the revegetation goals most effectively. This identification process will be in two steps: plant selection and site preparation and seeding.

IVc. Plant selection

Planning new seedings after construction provides an excellent opportunity to introduce low-maintenance plants that will satisfy goals. Consideration should be given to newer varieties of the standard species and species that are unique to AMC installations. The larger seed companies can work with land managers to help select or demonstrate beneficial species. Some examples of new low-growing varieties that have potential for low-maintenance slopes are Appalow lespedeza and the more drought-resistant varieties of the hard, red, chewings and sheep fescues. Before planting any species, inquire about its tolerance to the soils and climatic conditions existing at the site, as discussed in Sections IIb and e.

As with any organism, plants grow in close interaction with their immediate environment. Temperature-dependent variables of the environment that greatly affect plant survival, growth and reproduction include evaporation, insolation (sunlight), soil-forming processes, soil microbiota, plant nutrition, and animal pollinator species and activity. Factors influencing the amount and composition of the vegetation on ECMs include grazing history, soil nutrients, precipitation, slope exposures and steepness, proximity to forest and time since resurfacing. The plants on ridges and south-facing and upper slopes of ECMs are generally less dense than on north-facing slopes, probably due to greater moisture and heat stresses. Appendix E names herbaceous species that may be selected for revegetation purposes. Appendix F provides seed mixture recommendations for individual facilities. This type of information is also available from local university extension offices and the Soil Conservation Service (App. G).

Land managers may want to use native species in a revegetation project. This choice may be influenced by vegetation management goals, site use and location, availability of seeds or plants and relative costs. Some of the advantages and disadvantages of native and introduced species are shown in Table 10.

The quality of the planting material must be specified when available. It is preferable to use certified seeds that meet USDA standards. If these are unavailable, the manager should specify the place of origin, and the producer should be contacted to determine the seed's suitability for the site. Labels should list the minimum germination percentage and content of desirable species, the percentage of purity and the maximum percentage of weeds. Seeding rates will be given in the amount or weight of pure live seed (PLS) to apply per unit area (determined by multiplying the seed purity percentage by the germination percentage).

Table 10. Advantages and disadvantages of native vs introduced species.

	Advantages	Disadvantages
Native species	1) Well adapted 2) Lower maintenance costs 3) Blend in well with surrounding environment 4) Wildlife food and cover	1) More expensive (if active planting required) 2) Generally slower establishment or growth rates 3) Limited availability for most species 4) Greater uncertainty about characteristics
Introduced species	1) Generally inexpensive 2) Very rapid growth rates for some 3) Well-known characteristics 4) More adaptable for recreational areas 5) Readily available 6) Better palatability and digestibility 7) Less flammable	1) Higher maintenance costs to ensure persistence 2) May require higher fertilizer rates 3) Greater potential to become weeds 4) Higher visibility 5) May alter wildlife patterns (e.g., feeding, nesting, migration)

IVd. Site preparation and seeding

IVd1. Timing of establishment practices

Some revegetation activities, such as procurement of materials and the use of equipment time and labor, need to be scheduled as far in advance as possible to allow maximum flexibility, improve equipment utilization, and lessen the likelihood of costly delays, particularly those that impose seasonal constraints on revegetation. Site-specific plans should be written in advance so there will be adequate lead time to procure materials.

Planting should always take maximum advantage of the local growing season. The recommended planting or seeding times maximize the chances that emerging seedlings and transplants will encounter optimum temperatures and moisture and will survive through the winter. Optimum temperatures for seed germination are shown in Table 11. Both spring and fall may provide optimum temperatures. It is important, however, to know if the chosen species is better adapted to either a spring or fall seeding.

IVd2. Seeding considerations and techniques

Many of the treatments discussed here require specialized equipment. A small crawler tractor, bulldozer or conventional farm tractor is usually required. Soil preparation equipment depends on the site and tillage depth desired but could include a chisel plow, a conventional plow or a disk to loosen the surface soil and to mix amendments into the soil. Fertilizers are usually broadcast over the soil surface with a centrifugal or gravity-flow spreader, drilled into the soil, broadcast with a hydromulcher or applied aerially. Soil amendments, such as limestone, compost or manure, are also usually broadcast and then harrowed into the soil. Seeding is usually performed with a drill or cultipacker on more level sites and with a hydroseeder on steep slopes. Transplanting usually requires hand labor. Mulch may be spread by a hydromulcher, a blower or a manure spreader. It is important that operations, particularly in later stages, be on the contour, since water retention is important and erosion is a possibility.

Unless there are special goals or characteristics of the site, it is generally preferable to be as flexible as possible regarding equipment. Functional requirements such as "seedbeds must be left uncompacted and roughened" and "seed and fertilizer must be incorporated into the upper two inches of soil" must be clearly stated in bid requests. This allows the contractor to choose the most cost-effective types of equipment to meet the contract requirements. Figure 6 and Appendix C should be used while developing a seeding contract and guide.

In cold climates a decision must then be made concerning the seeding schedule, since timing may be crucial for the successful establishment of grasses and legumes for controlling soil erosion on ECMs. Revegetating in the fall requires the scheduling of seeding and mulching for either permanent or dormant seedings. Permanent seedings must be early enough to permit seedling establishment and avoid winterkill; dormant seedings must be late enough in the fall to delay germination until spring.

There is a one- to two-month period between the latest date for permanent seeding and the earliest date for dormant seeding. If seeding occurs between these dates, there is an increased risk of seedling mortality due to low fall and winter tempera-

Table 11. Optimum temperatures for seed germination of common turfgrass. (Adopted from the Association of Official Seed Analysts 1962.)

Turfgrass species	*Optimum temperatures for seed germination* (°F)*
Bahiagrass	86–95
Bentgrass:	
colonial	59–86
creeping	59–86
velvet	68–86
Bluegrass:	
annual	58–86
bulbous	50
Canada	59–86
Kentucky	59–86
rough	68–86
Buffalograss	68–95
Fescue:	
chewings	69–77
hair	50–77
meadow	68–86
red	59–77
sheep	59–77
tall	68–86
Gamma:	
blue	68–86
sideoats	59–86
Manilagrass	95–68
Orchardgrass	68–86
Redtop	68–86
Ryegrass:	
Italian	68–86
perennial	68–86
Smooth brome	68–86
Timothy	68–86
Western wheatgrass	59–86

* Temperatures separated by a dash indicate an alternation of temperature; the first numeral is for approximately 16 hr and the second for approximately 8 hr.

tures. Depending on the date of project completion and the site, permanent or dormant seedings are more desirable than seeding within the transition period. Table 11 shows the optimum soil temperatures for seed germination for various northern agronomic grasses; this information is useful in selecting seeding dates, particularly in conjunction with knowledge of cool vs. warm season stress tolerance and frost-heaving potential.

Temporary revegetation is used to stabilize slopes when permanent measures cannot yet be established, due to an incorrect seeding time or the failure of an ECM due to soil slippage. Temporary seedings may require heavy fertilization and seeding. Temporary physical stability measures, such as installation of geofabrics, mulches and stabilizers and culverts, may be needed after a site is disturbed and before permanent vegetation steps begin. Short-term maintenance commences immediately after grading or when planting is completed. This may include protecting an ECM from grazing by erecting temporary fences. Close monitoring to correct early failures and to ensure success is recommended.

IVd3. Fertilizer and soil amendments

After ECMs are renovated and re-covered with soil, growing conditions can be improved to increase the rate of establishment and growth of plants. Applications of fertilizer before or during seeding will provide needed plant nutrients such as nitrogen, phosphorus and potassium. The rate of fertilizer applied will depend on the initial fertility of the soil and on estimated natural organic and micronutrient sources, as indicated by soil test results obtained some months before seeding. Sources of nutrients are shown in Tables 12–14. Commercially available mixtures should be used whenever possible to reduce costs.

Organic soil amendments are usually considered for improving fine- and coarse-textured soils. These include composted sewage sludge, native organics, manure or straw. They will improve plant growth in coarse soils by increasing soil water-holding capacity and nutrient retention and in fine-textured soils by increasing infiltration rates and improving soil aeration and structure.

IVd4. Mulches

On newly seeded sloping soils, mulches are beneficial in counteracting excessive or deficient moisture, as well as in protecting against soil crusting. Mulches retard soil erosion and seedwashing during heavy precipitation and retain moisture during dry periods. A mulch is most effective during the first growing season since its purpose is to promote seed germination and seedling establishment by maintaining a more nearly optimum soil temperature and moisture content and by reducing surface soil movement. These benefits are seldom effective after one growing season.

Many materials are used as mulches; hay or straw remain the most economical and popular (Table 15). The greatest drawback of hay and straw is that they may introduce weed seeds onto the site. Some of the other popular mulches include wood-

Table 12. Nitrogen, phosphorus and potassium carriers that may be used for seedbed fertilization. (Adapted from Davis 1969.)

Carrier	*Formula*	*% N, P_2O_4 or K_2O*
	Nitrogen carriers	
Ammonium chloride	NC_4Cl	26
Ammonia liquor	NH_4OH	22–25
Ammonium nitrate	NH_4NO_3	33.5
Ammonium sulfate	$(NH_4)_2SO_4$	21
Anhydrous ammonia	NH_3	82
Calcium cyanamide	$CaCN_2$	20
Calcium nitrate	$Ca(NO_3)_2 4H_2O$	15.5
Diammonium phosphate	$(NH_4)_2HPO_4$	18–21
Monoammonium phosphate	$NH_4H_2PO_4$	11–12
Natural organics	—	—
Potassium nitrate	KNO_3	13
Sodium nitrate	$NaNO_3$	16
Urea	$CO(NH_2)_2$	45
Ureaform	—	38
	Phosphorus carriers	
Basic phosphate slag	—	10–12
Bonemeal	—	—
Calcium metaphosphate	$Ca(PO_3)_2$	62–66
Diammonium phosphate	$(NH_4)_2HPO_4$	46–54
Mixed fertilizers	—	—
Monoammonium phosphate	$NH_4H_2PO_4$	41–52
Phosphoric acid	$(H_3PO_4$ (in water)) SO_4	52 (usual form)
Superphosphate	$CaH(PO_4)_2H_2O+2CaSO_4H_2O$	18–24
Triple superphosphate	$3CaH_4(PO_4)_2$	37–53
	Potassium carriers	
Hardwood ashes	—	3–8
Mixed fertilizers	—	—
Potassium chloride (muriate of potash)	KCL	60–62
Potassium nitrate	KNO_3	44
Potassium sulfate	K_2SO_4	50

based materials (excelsior, wood chips, shredded bark), fabric or mats (jute, excelsior, woven paper), manure, sewage sludge and wood cellulose fiber. Most mulch materials require tacking to keep them in place. This may be a netting staked or stapled into the ground, an adhesive agent sprayed over the mulch, or straw or hay pressed into the soil surface by a "mulch coulter."

IVe. Evaluating success

The warranty period for determining if a seeding operation was successful is usually up to a year after seeding is completed. The criteria for determining success can include a simple visual observation or a count of the number of sown plants per unit area (ft^2). Both methods require inspectors who can recognize the types of plants sown when they are in the seedling stage. Simple visual observations are not recommended, however, since they are too subjective and can be debated.

Counting the number of plants per unit area is the most accurate method since it is quantitative. The number of pure live seed (seed that will germinate) sown per unit area should be determined, and a fraction of this number should be guaranteed by the contractor (see Section IVd). The actual number

Table 13. Approximate N, P, K content of certain natural organic fertilizer materials. (After Davis 1969.)

*Material**	*Total N (%)*	*Total P_2O_5 (%)*	*Total K_2O (%)*
Animal byproducts			
Blood, dried	13.0	2.0	1.0
Bone, dissolved	2.0	15.0	—
Bone meal, raw	4.0	22.5	—
Bone meal, steamed	2.5	25.0	—
Fish scrap, acidulated	6.0	6.0	—
Fish scrap or meal, dried	9.5	7.0	—
Hoof and horn meal	14.0	1.0	**
Tankage, animal	7.0	10.0	0.5
Tankage, process	9.0	0.5	—
Wool waste	3.5	0.5	2.0
Excreta			
Guano, bat	8.5	5.0	1.5
Guano, Peruvian	13.0	12.0	2.5
Manure, cattle, dried	2.0	1.5	2.0
Manure, horse, dried	2.0	1.5	1.5
Manure, poultry, dried	5.0	3.0	1.5
Manure, sheep, dried	2.0	1.5	3.0
Sewage sludge, dried	2.0	2.0	—
Sewage sludge, activated	6.0	3.0	0.5
Plant residues			
Castor pomace	5.5	1.5	1.5
Cotton seed meal	7.0	3.0	2.0
Garbage tankage	2.5	3.0	1.0
Linseed meal	5.5	2.0	1.5
Rapeseed meal	5.5	2.5	1.5
Soybean meal	7.0	1.5	2.5
Tobacco stems	2.0	0.5	6.0
Tung meal	5.0	1.5	1.5

* Food and Agriculture Organization of the United Nations (1949). These materials vary widely in composition. The figures given are average of typical analysis.
** No data.

of plants to meet the requirements of a successful seeding is determined by the climatic area. Drier climates should have a lower number of plants per unit area. The actual number used should be developed with the assistance of a local county extension office.

The counts should be made after a sufficient amount of time has passed for a seed to germinate and become established. Counts are made by randomly selecting a number of areas. One sampling about one square yard per 0.25 acres should be sufficient. If seedlings cannot be identified, they may be brought into a greenhouse to increase their growth rate and improve the identification. Inspectors should also be aware of the types of plants sown so they can determine if those plants are present.

Evaluating success is the last chance in the plant establishment process to obtain an optimum plant cover. Poor plant stands that are not corrected at this time will result in more difficult and expensive plant management techniques. Land managers should work closely with inspectors to ensure that a suitable plant cover is obtained.

Table 14. Common fertilizer ratios and some typical fertilizer analyses for each ratio. (From Beard 1973.)

Ratio on an oxide basis	*Approximate fertilizer analysis* $N\text{-}P_2O_5\text{-}K_2O$	*Approximate fertilizer analysis* N-P-K	*Ratio on an elemental basis*
1–1–1	10–10–10	10–4–8	2.5–1–2
	15–15–15	15–6–12	
	20–20–20	20–8–16	
0–1–1	0–20–20	0–8–16	0–1–2
	0–25–25	0–10–20	
1–2–2	5–10–10	5–4.4–8.3	1.1–1–1.9
	10–20–20	10–8.7–16.6	
1–4–4	4–16–16	4–7–13.3	1–1.7–3.3
2–1–1	16–8–8	16–3.5–6.6	4.6–1–2
	20–10–10	20–4.4–8.3	
4–2–1	20–10–5	20–4.4–4.2	5–1–1
4–1–1	20–5–5	20–2–4	9–1–2
	24–6–6	24–2.6–5	
2.5–1.5–1	10–6–4	10–2.6–3.3	3–1–1
4–1–2	16–4–8	20–1.7–6.6	9.2–1–3.8
3.3–1–2.3	10–3–7	10–1.3–5.8	7.7–1–4.5
5–1–2	25–5–10	25–2.2–8.3	11–1–4

Table 15. Performance of various mulches and stabilizers used for re-establishing vegetation in undisturbed areas. (From Bradshaw and Chadwick 1980.)

Material	*Rate (tons/acre)**	*Persistence*	*Stabilization*	*Soil-water retention*
Mulches				
Excelsior	2.0	xxx	xxx	xxx
Wood shavings	2.0	xxx	xx	xx
Wood chips	4.5	xxx	xx	xxx
Bark shredded	2.0	xxxx	xx	xxx
Peat moss	1.0	xx	xx	xx
Jute netting	—	xxx	xxxx	xx
Corncobs	4.5	xxxx	xx	xx
Hay	1.5	xx	xx	xx
Straw	1.5	xxx	xx	xx
Fiberglass	0.5	xxxx	xxx	xx
Stabilizer/mulches				
Wood cellulose fiber (as slurry)	0.5–1.0	xxx	xxxx	xx
Sewage sludge (as slurry)	1.0–2.0	xx	xxx	xx
Stabilizers				
Asphalt (as 1:1 emulsion)	0.35	xx	xxx	xxx
Latex (as appropriate emulsion)	0.1	xx	xxx	x
Alginate or other colloidal carbohydrate (as emulsion)	0.1	xxx	xxx	x
Polyvinyl acetate (as 1:5 emulsion)	0.5	xxx	xxx	x
Styrene butadiene (as 1:20 emulsion)	0.25	xxx	xxx	x

key: xxxx = high; xxx = moderate; xx = low; x = nil

*Rates can be varied depending on circumstance but will affect soil-water capture and retention and seedling establishment.

APPENDIX A: LAND MANAGERS AT AMC FACILITIES WITH ECMs.

NAME	*LOCATION*	*LAND MANAGER*	*AUTOVON*
	ARMY AMMUNITION DEPOTS		
Ft. Wingate	NM	Adrian Bond	790-6330
Pueblo	CO	Gerald Webster	749-4227
Red River	TX	Bennie Murray	829-2379
Sacramento	CA	Ray Harris	839-2623
Savanna	IL	Bob Speaker	585-8533
Seneca	NY	Tom Enroth	489-5450
Sierra	CA	John Colberg	855-4729
Tobyhanna	PA	Randy Didier	795-6494
Tooele	UT	Mason Walker	790-2891
Umatilla	OR	Chuck Ryan	790-5343
Bluegrass	KY	Billye Haslett	745-6361
Letterkenny	PA	Randy Quinn	570-8438
Anniston	AL	Billy Burns	571-4217
	ARMY AMMUNITON PLANTS		
Badger	WI	George Graham	280-9212
Cornhusker	NE	Tom Jamison	939-3690
Hawthorne	NV	Jim Purrell	830-7590
Holston	TN	(vacant)	748-3544
Indiana	IN	(vacant)	366-7750
Iowa	IA	Winston Cooper	585-7903
Joliet	IL	Arthur Holz	696-2938
Kansas	KS	Richard Thomas	956-1435
Lake City	MO	Charles Triplett	463-9477
Longhorn	TX	Thomas Brantley	956-2231
Louisiana	LA	Paul Hagerty	637-5479
McAlester	OK	Bill Starry	956-6611
Milan	TN	Steve Stephenson	968-6474
Mississippi	MS	Don Bales	446-8792
Newport	IN	Phil Cox	369-1324
Picatinny	NJ	Roger Wentling	880-4691
Pine Bluff	AR	Charles Becker	966-2834
Radford	VA	Joanne Wills	931-7480
Ravenna	OH	Tim Morgan	346-3244
Sunflower	KS	James Freeman	720-3258
Twin Cities	MN	John Chudeck	798-1500
Volunteer	TN	Jim Fry	588-9109
Lone Star	TX	Dave Self	829-1308
	OTHER		
Aberdeen Proving Ground	MD	Roger Stoflet	298-2905
Dugway Proving Ground	UT	Michael Stamm	789-2155
White Sands Missile Range	NM	Daisan Taylor	258-6140
Jefferson Proving Ground	IN	Ken Knouf	480-7436
Redstone Arsenal	AL	Jesse Horton	746-3122

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APPENDIX C: WORKSHEETS FOR DEVELOPING A REVEGETATION PLAN.

Goal Assessment

1. List revegetation goals in order of priority.

____

____

____

____

____

____

2. Specify reasons for recommending each goal.

____

____

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Site Assessment

This section refers to post-disturbance conditions. The assessment should be performed as early as possible during the planning phase and again immediately before revegetation commences.

Stability

This assessment can be cursory if stability problems are minor or non-existent, but it should be more thorough for highly unstable sites.

3a. Determine the appropriate site characteristic for the site. Information can come from site plans or from an on-site inspection.

Site acreage or size ______________________________

Soil type (% clay, silt, sand/name) ______________________________

Rock or gravel cover (%) ______________________________

Slope degree ______________________________

Slope length ______________________________

Slope aspect ______________________________

Local climatic factors of significance in erosion ______________________________

____

____

b. Use the Universal Soil Loss Equation (see App. D) to estimate soil erosion potential at the site, assuming no revegetation measures are applied. Compare this to SCS figures for allowable soil loss.

____

4. What physical measures or site modifications can alleviate the stability problems?

____

____

____

Growth Potential

5a. Describe soil moisture capacity available for plant growth, considering soil type, water table, site shape and contours, and rainfall.

b. Describe pH and nutrient availability, determined through soil testing.

c. Describe climate and microclimate for plants at the site.

ι Describe potential long-term benefits or problems that may occur at the site.

Selection of Treatments

7. What proven revegetation techniques have been used in similar disturbances or areas?

8. Determine the plant materials to be used, considering the future use of the site and your site assessment.

9. Determine if and to what extent topsoil or fine-grained soil is to be respread over the site. Is tillage possible? If so, at what depth?

a. Is there enough topsoil to be worth saving? If not, is there fine-grained subsoil that should be saved?

b. Designate and list areas for stockpiling topsoil or subsoil.

10. Determine the types of soil treatments to be used, considering the future use of the site, your site assessment and the plant materials you selected.

	Type	*Application rate*
Fertilizer, regular or slow release for nitrogen (circle one)	______	______ lb/acre
Lime	______	______ ton/acre
Sulfur	______	______ lb/acre
Organic material	______	______ ton/acre
Fine-grained material or sand	______	______ in.
Mulch	______	______
Other	______	______

11. In what order will amendments and mulches be added to the soil? What activities will the final grade consist of?

____

____

____

____

12. What measures, if any, will be taken for temporary stabilization?

____

____

____

____

Cost Assessment

13. For the treatments in section C, estimate the following (contractor should be allowed flexibility in selecting equipment):

a. Equipment requirements

Type	*Quantity*	*Duration*	*Cost*

b. Labor requirements

Type	*Quantity*	*Duration*	*Cost*

14. Estimate costs.

	Per acre	Site total
Soil amendments		
Fertilizer	____________	____________
Lime or sulfur	____________	____________
Organic material	____________	____________
Fine-grained material or sand	____________	____________
Mulch	____________	____________
Other ____________	____________	____________
Plant materials	____________	____________
Irrigation water	____________	____________
Equipment	____________	____________
Labor	____________	____________
Maintenance	____________	____________
TOTAL	____________	____________

15. Is the total cost within the budget? If not, modify goals, select new treatments and reassess costs.

Scheduling

16. Set the target dates. Revise this section periodically to reflect changes in construction schedules.

	Target date
Procure plant materials	______________
Procure soil amendments	
Fertilizer	______________
Lime or sulfur	______________
Organic material	______________
Fine-grained material or sand	______________
Mulch	______________
Other ______________	______________
Arrange for equipment	______________
Arrange for labor	______________
Add soil amendments	______________
Final grading	______________
Planting	______________
Irrigation	______________
Reassessment (have success criteria been met?)	______________

APPENDIX D: TECHNIQUES FOR ESTIMATING SOIL EROSION.

The universal soil loss equation (USLE) is used to estimate soil loss due to hydraulic erosion (Wischmeier and Smith 1965):

$$A = RKLSCP$$

where A = predicted annual soil loss (ton/acre-yr)
R = rainfall factor
K = soil erodibility factor (ton/acre-yr)
L = slope length factor
S = slope gradient factor
C and P = cropping-management and erosion-control-practice factors, each of which have a value of 1 and are not considered in estimating soil losses on nonagricultural land (Wischmeier 1976).

Numerical values for each of the factors R, K, L and S have been compiled in tables that are available at county or local Soil Conservation Service offices. This method estimates sheet and rill erosion. It does not account for large quantities of soil material that may be lost by gully erosion resulting from heavy concentrations of runoff water. Some factors may have to be modified for certain situations. For example, soil loss can be reduced by lowering K through additions of organics, sand or other physical materials, lowering L by terracing or adding water bars, or lowering S by contouring.

An analogous equation can be used to predict wind erosion losses (Skidmore and Woodruff 1968, Woodruff and Siddoway 1965):

$$E = I', K', C', L', V'$$

where E = predicted annual soil loss (ton/acre-yr)
I' = soil erodibility factor (ton/acre-yr)
K' = soil ridge roughness factor
C' = climatic factor
L' = width of field factor
V' = vegetative cover factor.

Maximum permissible soil loss values for particular sites can be obtained at local USDA Soil Conservation Service offices.

APPENDIX E. VEGETATION COMMONLY USED FOR REVEGETATION (EPA 625/3-76-006).

Table E1. Characteristics of commonly used grasses[a] for revegetation purposes.

Common name	Botanical name	Season: Cool	Season: Warm	Season: Dry (not droughty)	Site suitability: Well drained	Site suitability: Moderately well drained	Site suitability: Somewhat poorly drained	Site suitability: Poorly drained	Growth habit[b]	pH range[c]	Use suitability: Erodible areas	Use suitability: Waterways and channels	Use suitability: Agriculture[d]	Remarks
Bahiagrass	*Paspalum notatum*		X	X	X	X			P	4.5-7.5	X	X	X	Tall, extensive root system. Maintained at low cost once established. Able to withstand a large range of soil conditions. Scarify seed.
Barley	*Hordeum vulgare*	X			X	X			A	5.5-7.8	X		X	Cool season annual. Provides winter cover.
Bermuda grass	*Cynodon dactylon*		X	X	X	X	X		P	4.5-7.5	X	X	X	Does best at a pH of 5.5 and above. Grows best on well drained soils, but not on waterlogged or tight soils. Propagated vegetatively by planting runners or crowns.
Bluegrass, Canada	*Poa compressa*	X		X	X	X			P	4.5-7.5	X		X	Does well on acid, droughty, or soils too low in nutrients to support good stands of Kentucky bluegrass.
Bluegrass, Kentucky	*Poa pratensis*	X			X	X	X		P	5.5-7.0	X	X	X	Shallow rooted; best adapted to well-drained soils of limestone origin.
Bluestem, big	*Andropogon gerardi*		X		X	X	X		P	5.0-7.5	X		X	Strong, deep rooted, and short underground stems. Effective in controlling erosion.
Bluestem, little	*Andropogon scoparius*		X		X	X			P	6.0-8.0	X		X	Dense root system; grows in a clump to 3 feet tall. More drought tolerant than big bluestem. Good surface protection.
Bromegrass, field	*Bromus arvensis*	X			X	X	X		A	6.0-7.0	X		X	Good winter cover plant. Extensive fibrous root system. Rapid growth and easy to establish.
Bromegrass, smooth	*Bromus inermis*	X		X	X	X	X		P	5.5-8.0	X	X	X	Tall, sod forming, drought and heat tolerant. Cover seed lightly.
Buffalograss	*Buchloe dactyloides*		X			X	X		P	6.5-8.0	X		X	Drought tolerant. Withstands alkaline soils but not sandy ones. Will regenerate if overgrazed.
Canarygrass, reed	*Phalaris arundinacea*	X		X	X	X	X	X	P	5.0-7.5	X	X	X	Excellent for wet areas, ditches, waterways, gullies. Can emerge through 6 to 8 inches of sediment.
Deertongue	*Panicum clandestinum*		X	X	X	X	X	X	P	3.8-5.0	X	X		Very acid tolerant; drought resistant. Adapted to low fertility soils. Volunteers in many areas. Seed not available.
Fescue, creeping red	*Festuca rubra*	X		X	X	X	X		P	5.0-7.5	X	X	X	Grows in cold weather. Remains green during summer. Good seeder. Wide adaptation. Slow to establish.
Fescue, tall	*Festuca arundinacea*	X			X	X	X		P	5.0-8.0	X	X	X	Does well on acid and wet soils of sandstone and shale origin. Drought resistant. Ideal for lining channels. Good fall and winter pasture plant.
Grama, blue	*Bouteloua gracilis*		X	X	X	X	X		P	6.0-8.5	X			More drought resistant than sideoats grama. Sod forming. Extensive root system. Poor seed availability.
Grama, sideoats	*Bouteloua curtipendula*		X		X	X			P	6.0-7.5	X		X	Bunch forming; rarely forms a sod. May be replaced by blue grama in dry areas. Feed value about the same as big bluestem. Helps control wind erosion.
Indian grass	*Sorgastrum nutans*		X			X	X		P	5.5-7.5	X		X	Provides quick ground cover. Rhizomatous, tall. Seed available.
Lovegrass, sand	*Eragrostis trichodes*		X		X				P	6.0-7.5	X		X	A bunchgrass of medium height. Adaptable to sandy sites. Good for grazing. Fair seed availability.
Lovegrass weeping	*Eragrostis curvula*		X	X	X	X	X		P	4.5-8.0	X			Bunchgrass, rapid early growth. Grows well on infertile soils. Good root system. Low palatability. Short-lived in Northeast.

Table E1. Characteristics of commonly used grasses[a] for revegetation purposes (cont'd).

Common name	Botanical name	Season			Site suitability				Growth habit[b]	pH range[c]	Use suitability			Remarks
		Cool	Warm	Dry (not droughty)	Well drained	Moderately well drained	Somewhat poorly drained	Poorly drained			Erodible areas	Waterways and channels	Agriculture[d]	
Millet, foxtail	*Setaria italica*		X	X	X	X			A	4.5-7.0	X		X	Requires warm weather during the growing season. Can tolerate drought. Good seedbed preparation important.
Oats	*Avena sativa*	X		X	X				A	5.5-7.0	X		X	Bunch forming. Winter cover. Requires nitrogen for good growth.
Oatgrass, tall	*Arrhenatherum elatius*	X		X	X				P	5.0-7.5	X		X	Short-lived perennial bunchgrass, matures early in the spring. Less heat tolerant than orchardgrass except in Northeast. Good on sandy and shallow shale sites.
Orchardgrass	*Dactylis glomerata*	X		X	X	X	X		P	5.0-7.5	X		X	Tall-growing bunchgrass. Matures early. Good fertilizer response. More summer growth than timothy or bromegrass.
Redtop	*Agrostis alba*	X		X	X	X	X	X	P	4.0-7.5	X	X	X	Tolerant of a wide range of soil fertility, pH, and moisture conditions. Can withstand drought; good for wet conditions. Spreads by rhizomes.
Rye, winter	*Secale cereale*	X		X	X	X			A	5.5-7.5	X		X	Winter hardy. Good root system. Survives on coarse, sandy spoil. Temporary cover.
Ryegrass, annual	*Lolium multiflorum*	X			X	X	X		A	5.5-7.5	X		X	Excellent for temporary cover. Can be established under dry and unfavorable conditions. Quick germination; rapid seedling growth.
Ryegrass, perennial	*Lolium perenne*	X			X	X	X		P	5.5-7.5	X		X	Short-lived perennial bunchgrass. More resistant than weeping love or tall oatgrass.
Sandreed, prairie	*Calamovilfa longifolia*		X	X	X				P	6.0-8.0	X			Tall, drought tolerant. Can be used on sandy sites. Rhizomatous. Seed availability poor.
Sudangrass	*Sorghum sudanense*		X	X	X	X	X		A	5.5-7.5	X		X	Summer annual for temporary cover. Drought tolerant. Good feed value. Cannot withstand cool, wet soils.
Switchgrass	*Panicum virgatum*		X		X	X	X		P	5.0-7.5	X	X	X	Withstands eroded, acid and low fertility soils. Kanlow and Blackwell varieties most often used. Rhizomatous. Seed available. Drainageways, terrace outlets.
Timothy	*Phleum pratense*	X			X	X	X	X	P	4.5-8.0	X		X	Stands are maintained perennially by vegetative reproduction. Shallow, fibrous root system. Usually sown in a mixture with alfalfa and clover.
Wheat, winter	*Triticum aestivum*	X		X	X	X	X		A	5.0-7.0	X		X	Requires nutrients. Poor growth in sandy and poorly drained soils. Use for temporary cover.
Wheatgrass, tall	*Agropyron elongatum*	X		X	X	X	X	X	P	6.0-6.0	X	X	X	Good for wet, alkaline areas. Tolerant of saline conditions. Sod forming. Easy to establish.
Wheatgrass, western	*Agropyron smithii*	X		X	X	X	X	X	P	4.5-7.0	X	X	X	Sod forming, spreads rapidly, slow germination. Valuable for erosion control. Drought resistant.

[a]Grasses should be planted in combination with legumes. Seeding rates, time, and varieties should be based on local recommendations.

[b]P = perennial; A = annual.

[c]Many species survive and grow at lower pH; however, optimum growth occurs within these ranges.

[d]Hay, pasture, green manure, winter cover, and nurse crops are primary agricultural uses.

Note.—Prepared in cooperation with Soil Conservation Service plant material specialists and State conservationists.

Table E2. Characteristics of commonly used legumes[a] for revegetation purposes.

Common name	Scientific name	Season			Site suitability				Growth habit[b]	pH range[c]	Use suitability			Remarks
		Cool	Warm	Dry	Well drained	Moderately well drained	Somewhat poorly drained	Poorly drained			Erodible areas	Waterways and channels	Agriculture[d]	
Alfalfa	*Medicago sativa*	X		X	X	X			P	6.5-7.5	X		X	Requires high fertility and good drainage.
Clover, Alsike	*Trifolium hybridium*	X			X	X	X	X	P	5.0-7.5	X		X	Good for seeps and other wet areas. Dies after 2 years.
Clover, red	*Trifolium pratense*	X			X	X			P	6.0-7.0	X		X	Should be seeded in early spring.
Clover, white	*Trifolium repens*	X			X	X	X		P	6.0-7.0	X		X	Stand thickness decreases after several years.
Flatpea	*Lathyrus sylvestris*	X		X	X	X	X		P	5.0-6.0	X			Seed is toxic to grazing animals. Good cover.
Lespedeza, common	*Lespedeza striata*		X		X	X			A	5.0-6.0	X			Low-growing, wildlifelike seed. Kobe variety most often used. Acid tolerant.
Lespedeza, Korean	*Lespedeza stipulacea*		X	X	X	X	X		A	5.0-7.0	X			Less tolerant of acid soils than common lespedeza.
Lespedeza, sericea	*Lespedeza cuneata*		X	X	X	X	X		P	5.0-7.0	X	X		Woody, drought tolerant, seed should be scarified. Bunchlike growth.
Milkvetch, cicer	*Astragalus cicer*			X	X	X	X		P	5.0-6.0	X		X	Drought tolerant. Low growing. No major diseases. Hard seed coat.
Sweetclover, white	*Melilotus alba*	X		X	X	X			B	6.0-8.0	X		X	Requires high-pH spoil. Tall growing. Produces higher yields. Less reliable seed production.
Sweetclover, yellow	*Melilotus officinalis*	X		X	X	X			B	6.0-8.0	X		X	Requires high-pH spoil. Tall growing. Can be established better than white sweetclover in dry conditions.
Trefoil, birdsfoot	*Lotus corniculatus*	X		X	X	X	X		P	5.0-7.5	X		X	Survives at low pH. Inoculate with special bacteria. Plant with a grass.
Vetch, crown	*Coronilla varia*	X		X	X	X			P	5.5-7.5	X		X	Excellent for erosion control. Drought tolerant. Winter hardy.
Vetch, hairy	*Vicia villosa*	X		X	X	X			A	5.0-7.5	X		X	Adapted to light sandy soils as well as heavier ones. Used most often as a winter cover crop.

[a]Legumes should be inoculated. Use four times normal rate when hydroseeding.

[b]A = annual; B = biennial; P = perennial.

[c]Many species survive and grow at lower pH; however, optimum growth occurs within these ranges.

[d]Hay, pasture, green manure.

Note.—Prepared in cooperation with Soil Conservation Service plant material specialists and State conservationists.

APPENDIX F. SEED MIXTURE RECOMMENDATIONS FOR INDIVIDUAL FACILITIES.

Facility	*Seed mixture*	*Rate (lb/acre)*
Aberdeen Proving Ground	birdsfoot trefoil	20
Letterkenny	tall fescue	25
New Cumberland	fine fescue	50
Picatinny	perennial ryegrass	5
Seneca		
Tobyhanna		
Badger	tall fescue	20
Indiana	Kentucky bluegrass	20
Iowa	red or white clover	5
Jefferson	perennial ryegrass	5
Joliet	fine fescue	20
Newport		
Ravenna		
Holston	serecia lespedeza	20
Blue Grass	tall fescue	50
Radford	fine fescue	50
Volunteer	perennial ryegrass	5
McAlester	weeping lovegrass	6
	switchgrass	3
	little bluestem	3
	bermudagrass	3
	buffalograss	3
	sideoats grama	3
Anniston	bermudagrass	40
Louisiana	serecia lespedeza	
Mississippi	or clover	20
Pine Bluff		
Red River		
Louisiana		
Longhorn		
Iowa	tall fescue	40
Kansas	fine fescue	40
Lake City	birdsfoot trefoil	10
Sunflower	switchgrass	10
Ft. Wingate	Lehman lovegrass	2
Hawthorne	Boer lovegrass	2
Sierra	blue grama	2
Navajo	western wheatgrass	8
	crested wheatgrass	5
	pubescent wheatgrass	4
	sand dropseed	4

Facility	*Seed mixture*	*Rate (lb/acre)*
	indian ricegrass	4
	smooth bromegrass	5
Umatilla	hard fescue	25
	crested wheatgrass	10
	big bluestem	10
	perennial ryegrass	5
Pueblo	crested wheatgrass	14
Tooele	streambank wheatgrass	10
	sand dropseed	6

NOTE: This list provides only species names. Suitable cultivars that perform well within your climatic areas should be selected. Assistance is available at your local county extension office or at Plant Material Centers operated by the Soil Conservation Service. The SCS centers are listed in Appendix G.

APPENDIX G: PLANT MATERIALS CENTERS, SOIL CONSERVATION SERVICE.

ALASKA, HCO2, Box 7400, Palmer 99645, (907) 745-4469

ARIZONA, 3241 North Romero Rd., Tucson 85705, (602) 670-6491

ARKANSAS, Rt. 2, Box144B, Booneville 72927, (501) 675-5182

CALIFORNIA, P.O. Box 68, 21001 N. Eliot Rd., Lockeford 95237, (209) 727-5319/3205

COLORADO, P.O. Box 448, 5538 Rio Blanco County Road 4, Meeker 81641, (303) 878-5003

FLORIDA, 14119 Broad Street, Brooksville 34601, (904) 754-0303

GEORGIA, Route 6, Box 417, Morris Drive, Americus 31709, (912) 924-2286

HAWAII, P.O. Box 236, Hoolehua, Molokia 96729, (808) 567-6378

IDAHO, P.O. Box AA, 1693 South 2700 West, Aberdeen 83210, (208) 397-4181

KANSAS, 3800 S. 20th St., Manhattan 66502, (913) 539-8761

KENTUCKY, University Dr., Quicksand 41363-9999, (606) 666-5069

LOUISIANA, P.O. Box 2202, S. Lafourche Airport Rd., Galliano 70354, (504) 475-5280

MICHIGAN, 7424 Stoll Road, East Lansing 48823-9807, (517) 641-6300

MISSISSIPPI, Route 3, Box 215A, Coffeeville 38922, (601) 675-2588

MISSOURI, Route 1, Box 9, Elsberry 63343, (314) 898-2012

MONTANA, Route 1, Box 1189, Bridger 59014-9718, (406) 662-3579

NEW JERSEY, 1536 Rt. 9N, Cape May Court House 08210, (609) 465-5901

NEW MEXICO, 1036 Miller Street, SW Los Lunas 87031, (505) 865-4684

NEW YORK, Box 360A, RDI, Route 352, Corning 14830, (607) 562-8404

NORTH DAKOTA, P.O. Box 1458, Bismarck 58502, (701) 223-8536/9024

OREGON, 3415 Northeast Granger Avenue, Corvallis 97330, (503) 757-4812/4825

TEXAS, Route 1, Box 155, Knox City 79529-9752, (817) 658-3922

WASHINGTON, Hulbert Agricultural Science Bldg., Rm. 104, Washington State University, Pullman 99164-6411, (509) 335-7376

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The purpose of these guidelines is to assist land managers in establishing and maintaining vegetation on earth-covered magazines (ECMs) in a safe, efficient and cost-effective manner. Although the vegetation management procedures discussed here are intended primarily for conventional storage ECMs, not those used for special weapons, many of the general procedures and principles presented apply to both types. In humid areas a healthy vegetative cover on ECMs is the primary factor in maintaining the stable soil cover that is required to meet safety standards. Thus, a vegetation management planning process is presented that assists land managers in defining management goals, assessing climatic and soil factors and evaluating vegetation options. Specific methods and procedures that have proven successful for maintaining and re-esta[illegible]ing an effective vegetation cover are outlined. Other methods used to stabilize the ECM soil cover in dry [illegible]mates, where cost-effective maintenance of vegetation can be difficult to impossible, are briefly discussed as well.

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